DOCUMENT RESUME

ED 167 635 TM 008 483

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TITLE Influence of Cognitive Style and Training on Tasks Requiring the Separation of Variables Schema.
PUB DATE Mar 78
NOTE 17p.; Paper presented at the Annual Meeting of the American Educational Research Association (62nd, Toronto, Ontario, Canada, March 27-31, 1978)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Abstract Reasoning; Cognitive Processes; *Cognitive Style; Foreign Countries; Individual Differences; *Logical Thinking; Performance Factors; *Problem Solving; Secondary Education; *Task Analysis; *Thought Processes; *Training
IDENTIFIERS England; Field Dependence Independence; Pascual Leone (J); Piaget (Jean); Portable Rod and Frame Test

ABSTRACT

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INFLUENCE OF COGNITIVE STYLE AND TRAINING ON TASKS REQUIRING THE SEPARATION OF VARIABLES SCHEMA

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TM008 483

Paper presented at American Educational Research Association Meeting, Toronto, Ontario, Canada, March, 1978.

*The author would like to thank the principal, teachers, and students who participated in these studies. Special thanks are due David I. Levine, Herbert D. Thier, and Steven Pulos for help in design, operation, and interpretation of the various experiments. The author gratefully acknowledges help from Lina Villavicencio, Perla Tayko, Diane Epstein, and Sue Arnold for data collection and program operation.

**This material is based upon research supported by the National Science Foundation under Grant No. SED74-18950. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation.

Printed in U.S.A.

Abstract

It has been suggested that cognitive style interacts with performance on tasks measuring formal thought (Pascual-Leone, Note 1). It is hypothesized that cognitive style interacts with task context rather than with the underlying formal thought processes. Experiments are reported to clarify the type of task that elicits an interaction and to determine whether such interactions can be altered by instruction in formal thought processes.

About 250 students age 12 to 16 participated in one of three experiments. Two tasks involving the separation of variables schema but contrasting contexts were administered to all subjects. In one context only information necessary for applying the separation of variables schema was presented. In another context the relevant information was embedded in irrelevant additional information. Cognitive style was measured in two experiments. In one experiment, subjects taught the separation of variables schema were compared to uninstructed subjects. Results support the hypothesis of the study: task context interacts with cognitive style and training or separation of variables does not appreciably affect performance on irrelevant context tasks.

A number of researchers have suggested that cognitive style or field dependency is an important factor in formal operational thought (Witkin, Moore, Goodenough, & Cox, 1977; Pascual-Leone, Note 1; Niemark, Note 2). Several hypotheses concerning the effect of cognitive style on performance have been put forth. Both Pascual-Leone and Witkin et al. suggest that cognitive style interacts with selection of information to be processed. Pascual-Leone (Note 1) points out that field dependent subjects see different information as salient for problem solving than field independent subjects. According to Pascual-Leone, in situations where conflicting information is available the field dependent person often processes inappropriate information. Witkin et al. (1977) suggest that field dependent people are less likely to use "mediators" or general principles to govern their information processing system. As Niemark (Note 2) points out, very few studies specifically correlate performance or formal operational reasoning tasks with cognitive style and these studies yield conflicting outcomes.

The series of experiments reported in this paper help to define what is meant by "conflicting information" informal tasks and how tasks with this characteristic are handled by subjects with different cognitive styles. In particular, these studies suggest that cognitive style interacts with question context in tasks requiring the separation of variable schema. It is suggested that question context is a factor which might contribute to low correlations between formal operational reasoning tasks (Linn, Note 3).

Tasks

The series of studies reported in this paper all use two tasks developed by the author. Both tasks require the subject to use the separation of variables schema described by Inhelder and Piaget (1958). Detailed

description of the tasks is found elsewhere (Levine & Linn, 1977). Both tasks involve spheres rolling down a ramp. In the first task, Controlling, the subject must decide whether or not to control one variable in an experiment; he is told to find out which of two spheres is best for hitting a target far. To be successful on Controlling, the subject must release the two spheres from the same position. In the second task, Screen, the subject is asked to analyze the results of an uncontrolled experiment; he is asked whether he has enough information to decide which of the two spheres is the best for hitting a target far. In this task the two spheres are released from different positions but the actual release of the spheres is concealed behind a screen. To be successful the subject must indicate that the release points could be different. Both Controlling and Screen concern the same phenomenon--deciding which of two spheres rolling down a ramp is the most powerful; the major difference between the two tasks concerns how the information is presented.

All responses were scored either success or failure.

Experiment 1

In a study reported elsewhere (Levine & Linn, 1977) the developmental characteristics of these tasks were assessed. This study is reported to establish the generalizability and stability of the tasks. Sixty subjects age 12, 14, and 16 in a comprehensive school near London, were randomly selected to participate in the study. The two tasks were administered in a single interview session. Results are shown in Figure 1. As can be seen, significant effects for age were found on both tasks (Controlling $z = 2.79$, $p<.01$; Screen $z = 3.18$, $p<.01$.) The unexpected finding that Screen was

considerably more difficult than Controlling for 12-year-olds but not older subjects is hypothesized to reflect either a change in functioning or some special experiences (Levine & Linn, 1977). It seemed appropriate to replicate the study using 13 and 15-year-old subjects.

Insert Figure 1 about here

Experiment II

The purpose of this study was to generalize the findings of Experiment I to 13 and 15 year-olds to demonstrate task stability and to investigate the hypothesis that the conflicting information in Screen might result in an interaction between cognitive style and question context. Since the information in Screen is presented in a conflicting context in the sense that the results of the experiment are emphasized but are not relevant to the solution, it seemed reasonable to hypothesize that cognitive style might influence performance. In particular the hypothesis is that poor performance on Screen is more likely for field dependent subjects than for field independent subjects.

Subjects were 125 randomly selected seventh and ninth grade students in a rural, blue-collar area in Northern California. All subjects received the portable Rod and Frame Test as a measure of cognitive style followed by Controlling and Screen.

As shown in Figure 1, 13 and 15-year-olds performed as predicted;

15-year-olds scored almost exactly between 14 and 16-year-olds, 13-year-olds just below 14-year-olds. Age differences were signitifcant for Controlling ($X^2 = 4.0$, $p < .05$) and Screen ($X^2 = 8.9$, $p < .01$). Also, 13-year-olds performed slightly but not significantly better on Controlling than on Screen, similar to the performance of 12-year-olds in Experiment I. However, these findings more reasonably suggest that 12-year-olds in Experiment I performed unexpectedly well on Controlling and as would be predicted for Screen. One hypothesis is that some aspect of the school program for the 12-year-olds in Experiment I accounts for their performance on Controlling. Information relevant to this hypothesis is gathered in Experiment III

Results for the cognitive style dimension are shown in Figure 2. The 9 subjects scoring above 41 on the Portable Rod and Frame were considered Field Dependent. The 15 scoring below 15 were considered Field Independent. The groups included equal numbers of males and equal numbers of 15-year-olds. As can be seen, no differences in performance on Controlling are found for the extreme cognitive style groups but field dependent subjects perform significantly less well than field independent subjects on Screen ($p < .05$, Fisher test). It appears that the conflicting context for the information in Screen interacts with cognitive style; no such interaction occurs for Controlling. Since cognitive style does not interact with Controlling, it is hypothesized that the conflicting context in Screen affects subjects' performance on a separation of variables task such that the separation of variables schema is not invoked. Thus, for field dependent subjects competence in using the separation of variables schema is not a factor in performance on Screen.

Insert Figure 2 about here

Experiment III

Experiment II suggested that cognitive style interacts with the embeddedness of information in the Screen. It was hypothesized that this was a performance rather than a competence interaction. If it is a performance interaction, then training on the separation of variables schema will not change the relationship between cognitive style and performance on Screen.

The results of Experiment II suggest that the performance of 12-year-olds on Controlling in Experiment I may be due to some kind of school experience. This hypothesis is investigated in Experiment III by training 12-year-old subjects to use the separation of variables schema.

In Experiment III the procedure was to take a group of 60 12-year-old students, assess their cognitive style using the Portable Rod and Frame, randomly assign them to three experimental conditions, provide different types of training for each group, and then administer Controlling and Screen. Subjects were middle-class, racially-mixed sixth graders in a Northern California school.

Training

Training consisted of the Piagetian Pendulum Task to assure that the three groups were equivalent in their ability to control variables, and then one procedure for each of the three groups. Details are given elsewhere (Linn, Note 3). Group I received "intervention": The subjects attended six 15-minute training sessions in which the concepts of variables, criticizing an experiment, and controlling an experiment were introduced using the lecture demonstration approach. Group II received what is called the "simultaneous" program: intervention plus twelve 45-minute sessions

where subjects carried out experiments using equipment on their own. Group III (controls) received the twelve 45-minute experimentation sessions only. In summary, the three conditions were: intervention alone, experimentation plus intervention, or experimentation alone.

Results and Discussion

As shown in Figure 3, the group receiving intervention was superior to the others ($X^2 = 9.02$, $p < .01$) on Controlling. No significant differences between groups on Screen were found. This suggests that training on application of the separation of variables schema does not generalize to questions involving conflicting information suporting the performance-competence hypothesis. It is possible that training specifically concerned with selection of information from conflicting contexts would affect performance on Screen.

Insert Figure 3 about here

Comparison of control Group III 12-year-olds in Experiment III to 12-year-olds in Experiment I, is difficult since the populations are not comparable. It is clear, however, that control 12-year-olds perform equally well on Controlling and Screen while trained 12-year-olds do better on Controlling than on Screen. These results suggest that the surprisingly successful performance of 12-year-olds on Controlling in Experiment I might well be due to specific school experiences.

It should be noted, that the outcome for Group II (intervention plus experimentation) is not as anticipated--subjects in this condition were no

better than control subjects. As discussed elsewhere (Linn, Note 4), it is possible that the intervention conflicted with the experimentation, thus providing subjects with a confusing view of controlling variables.

Cognitive style was investigated by using subjects in Groups I and II and comparing performance of the 10 subjects scoring above 41 to performance of the 10 subjects scoring below 15 as was done in Experiment II. Since subjects were assigned at random, extreme scorers comprised equal numbers of subjects from the two groups. In addition, the extreme scorers had equal numbers of males. As can be seen in Figure 2, results for Experiment III replicated the findings of Experiment II. As in Experiment II, the differences in performance for field dependent versus field independent individuals was significant for Screen ($p < .05$, Fisher test) but not for Controlling.

Does training on the separation of variables strategy alter the interaction between task context and cognitive style? Evidence from the trained subjects suggests that it does not, although the small numbers involved make definite conclusions difficult. Of the 4 field dependent trained subjects, one succeeded on Screen and 3 succeeded on Controlling. Of the 5 field independent trained subjects all succeeded on Controlling and 3 of 5 succeeded on Screen. Thus performance on Screen was comparable to that of untrained subjects while performance on controlling reflected the success of the training, lending further support to the performance-competence hypothesis.

Conclusions

The three experiments reported here indicate an interesting anomaly between performance on two tasks which ostensibly involve the same schema,

namely, separation of variables as defined by Piaget. These results suggest that cognitive style and context interact and that cognitive style influences some aspects of formal thought but not others. The major cha acteristic which differentiates Controlling and Screen concerns the conflicting available information. These results more clearly define the type of question context which can be considered conflicting. In particular the results of an uncontrolled experiment interfered with the ability of field dependent subjects to apply the separation of variables schema. These results suggest that whereas performance in conflicting contexts is influenced by cognitive style, it is also clear that use of the separation of variables schema is independent of cognitive style in contexts without embedded information. Thus one contributing factor in the low correlations between performance on formal reasoning tasks may be question context rather than comprehension of the necessary schema.

These results are consistent with Pascual-Leone's finding (Note 1) that field dependent subjects have difficulty with tasks which involve conflicting strategies and elaborate the findings of Dale (Note 5) and Neimark (1975) who suggest that cognitive style interacts with formal operational thought.

These results suggest the existance of three groups of subjects within a single age: those who are able to control on both Ramp and Screen; those who can control on Ramp but not on Screen; and those who cannot control. The group who can control on Ramp but not Screen is characterized by field dependency.

A strict Piagetian interpretation would only consider subjects who controlled on both tasks to possess the controlling scheme. If only those who control on both tasks are considered to possess the scheme then the training would be viewed as unsuccessful. This would be consistent

with Piaget's statements concerning the limited value of training in fostering logical thinking.

Another way to conceptualize this situation is to view cognitive style as a stable personality trait. It may be that the development of field dependent subjects differs from that of field independent subjects. By not separating these populations it is possible to confound development with personality style.

Because Piaget's data gathering style does not examine individual differences and does not look at age as a predictor of performance, confounding of development with individual differences may have contributed to replication problems. Piaget's (Inhelder and Piaget, 1958) distinction in the transition from concrete to formal thought between reasoning about real events as opposed to reasoning about all possible events reflects not a developmental trend but a personality characteristic. That is field dependent subjects tend to limit their reasoning to real events (the results of screen) while field independent subjects consider all the possible ways the results could have been achieved. This conceptualization is surely undercomplicated but is a possible confounding of crossectional research studies which deserves further investigation. Some support for this conceptualization comes from the success of Case (1974) in teaching field independent but not field dependent 8 year olds the separation of variables schema.

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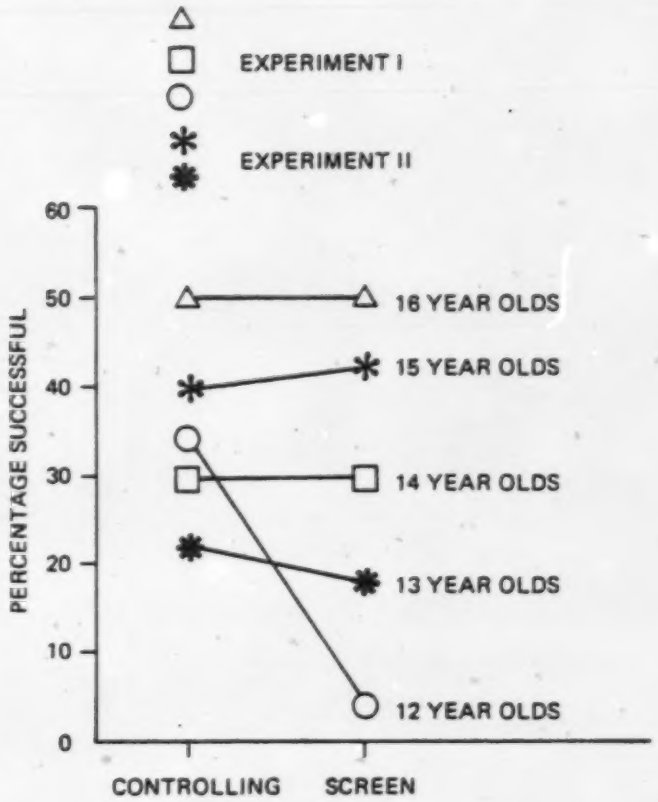

Figure 1. Performance of 12, 13, 14, 15, and 16-year-old subjects.

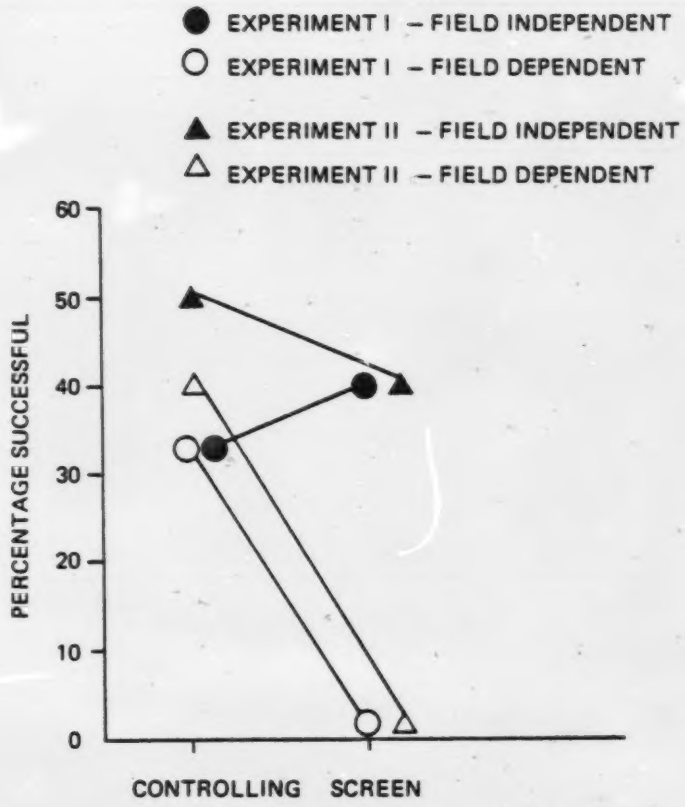

Figure 2. Performance of field dependent and field independent subjects.

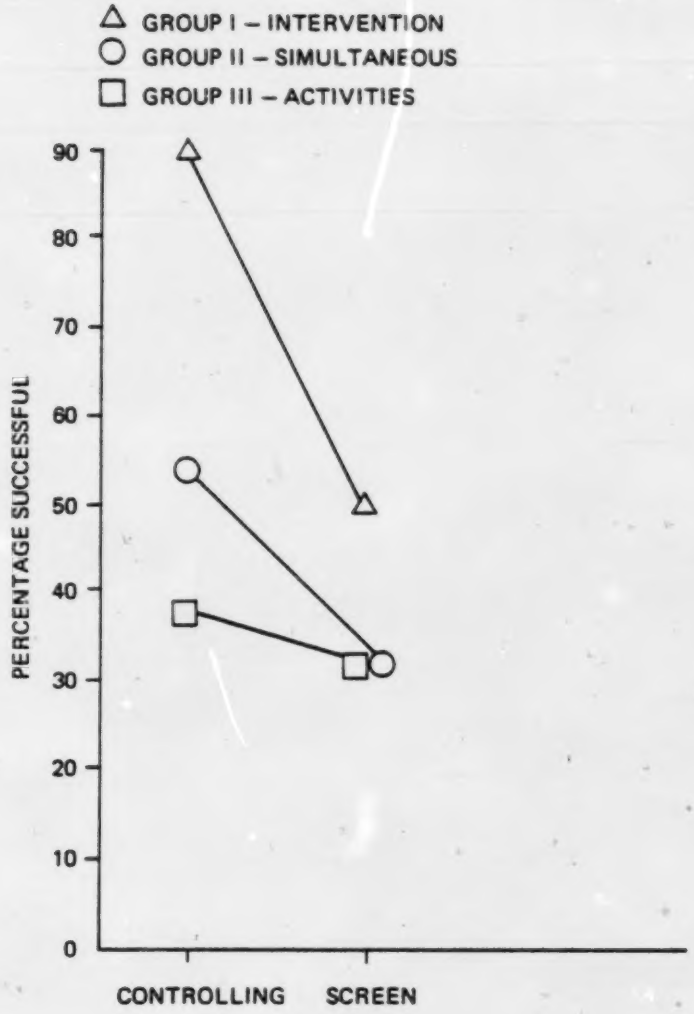

Figure 3. Performance of trained and untrained 12-year-old subjects in Experiment II.